Engineering Journal of Qatar University, Vol. 2, 1989.

"INVESTIGATION OF IN-SERVICE PARAMETERS INFLUENCING THE WEAR AND WEAR RATE FOR TWO RUBBING SURFACES"

By

A.Y. Kandeil and Essam H. Roushdy
Associate Professor Associate Professor

Faculty of Engineering, Qatar University,
Doha, Qatar - Arabian Gulf.

ABSTRACT

A study has been conducted on the volumetric wear and wear rate as well as the quality of the surfaces produced by rubbing brass and steel specimens. Effect of end pressure and total sliding distance between the two rubbed surfaces on both the surface parameters and the material wear rate have been investigated.

The surface parameters were measured using a (Talysurf−5) surface analyzer while wear rate values were obtained using a (pin and disk) type wear and friction testing machine. Experiments were conducted at disk speed of (102 rpm) for pin end pressure values between 2 and 12 bars.

Experimental results have been analyzed on an IBM-XT computer using SPSS-PC statistical package. The analyses revealed significant influence of the pin end pressure and the total sliding distance on the wear, wear rate and the roughness of the produced surface. Three regression equations representing those relations were deriven and the corresponding conclusions were drawn.

1. INTRODUCTION

The surface texture of a material plays a crucial role as the primary location of all interactions. The vertical microscopic structure of a surface consists of several layers in addition to the base material. These include structural changes resulting from machining or manufacturing operations, diffusion layer and a reaction layer [1], as shown in Fig.1. In addition to the vertical structure, there is the horizontal heterogeneity such as the different phases and/or grain orientations and composition. There is also the surface topography which is the form and extent of roughness and waviness. The surface is influenced by the nature of the material and its previous history of fabrication. One important factor to consider is the changes that take place to the surface during use. Little work has been published to quantify the changes of the surface texture parameters of two rubbing surfaces during use. The present paper addresses this topic.

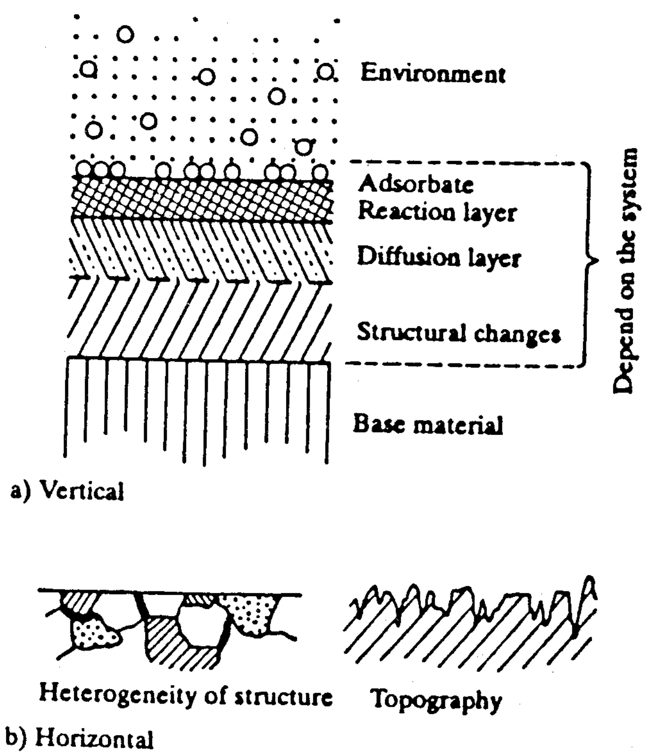


Fig. 1 : Schematic microstructure and topography of a system.

2. EXPERIMENTS

2.1 Wear Test Apparatus

Tests were performed on a pin and disc type machine described in reference [2]. Essentially, the machine consists of a disc shaped specimen carried on a mandrel where the two identical pins to be tested are pressed into contact with the opposite surfaces of the disc by means of hydraulic cylinders. The cylinders are mounted on a cross slide attached to the machine bed. The carriage is free to move in a direction perpendicular to the axis of the mandrel. The general configuration of the disc, pins and carriage is illustrated in Fig. 2. The carriage is located so that the pins lie verticallly below the axis of the disc at a radius of 40 mm.

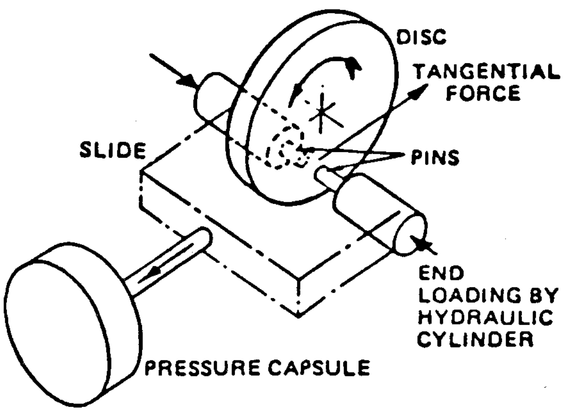


Fig. 2 : Configuration of Test Set-up.

The tangential force resulting from the friction between the pins and disc is measured by means of a pressure capsule connected to a pressure guage. An additional means of measuring the tangential force is provided by an electronic strain guage force transducer. The signal from the transducer permits continuous recording of the friction force on a chart recorder.

A hydraulic end loading is applied to the specimen pens by means of a precision dead-weight pressure tester. Five different end loads in the range 2 to 12 bars (200 to 1200 KN/m^2) were utilized in the present investigation. The machine is capable of providing 14 spindle speeds ranging from 25 rpm to 2150 rpm. An intermediate speed of 102 rpm was selected for the present investigation.

2.2 Tested Materials

The dimensions of the disc and pin specimens used in the present investigation are shown in Fig. 3. The discs were machined from free cutting mild steel with maximum carbon content of 0.15%, while the pins were machined from brass with 58% Cu, 3% pb and remainder Zn [2]. The hardness of the pin and disc materials was measured using Rockwell hardness tester to be 64 R_f and 97 R_b. respectively.

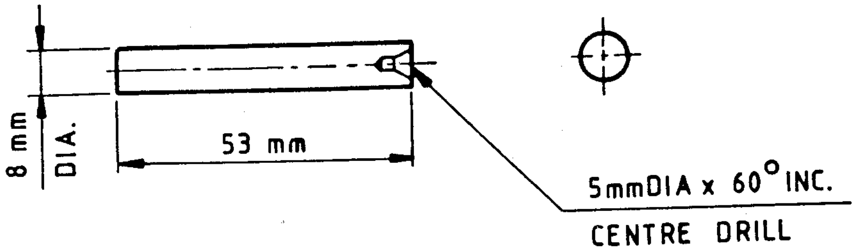
2.3 Experimental Procedure

i. Wear measurement

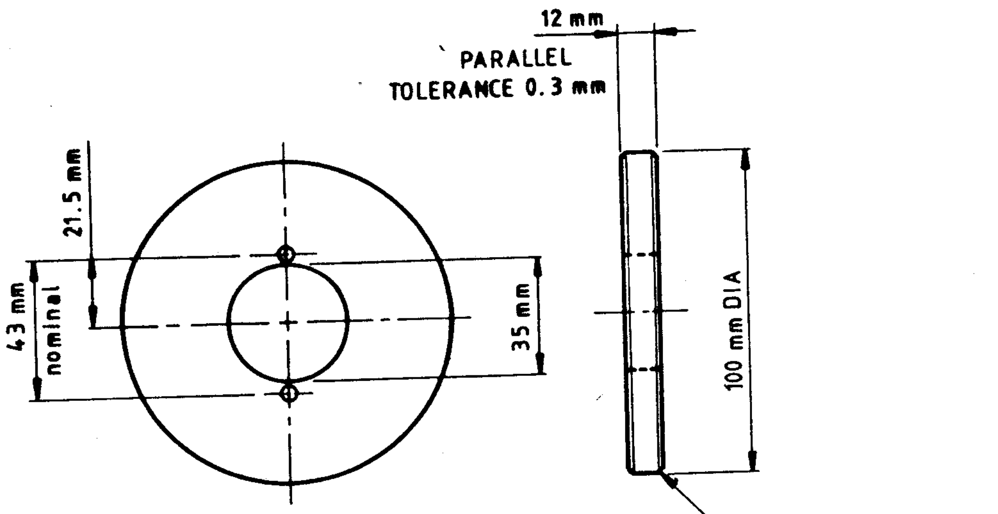
Wear of the brass specimens was measured by the following method. A conical hole, having an included angle of 60° and a maximum diameter of about 5 mm, was drilled in the end of the pin specimen, using a standard centre drill. Any wear of the end face results in a reduction in the maximum diameter of the cone and this reduction is directly proportional to the depth of wear. The hole diameter was measured at the start and end of each successive run by means of a microscope fitted with a graticule and a battery operated lamp. The comulative number of disc revolutions was measured by a digital counter.

ii. Surface texture measurement

The texture and parameters [3] of the pin surface, resulting after a specified disk revolutions, were plotted and measured using a Taylor-Hobson Talysurf- 5.



a) Pin



b) Disc

Fig. 3 : Test Specimens.

3. EXPERIMENTAL RESULTS

Volumetric wear of the pin specimens was calculated from the reduction in the conical diameter after each run and the results are plotted against sliding distance for the various end loads, as shown in Fig. 4. The relationship between wear and sliding distance is linear. Similar results are reported in [4]. Wear rates were deduced from Fig. 4 and the results are plotted in Fig. 5. Again a linear relationship is observed. The surface texture of the pin specimens along with the surface parameters after testing at the various end loads are shown in Fig. 6.

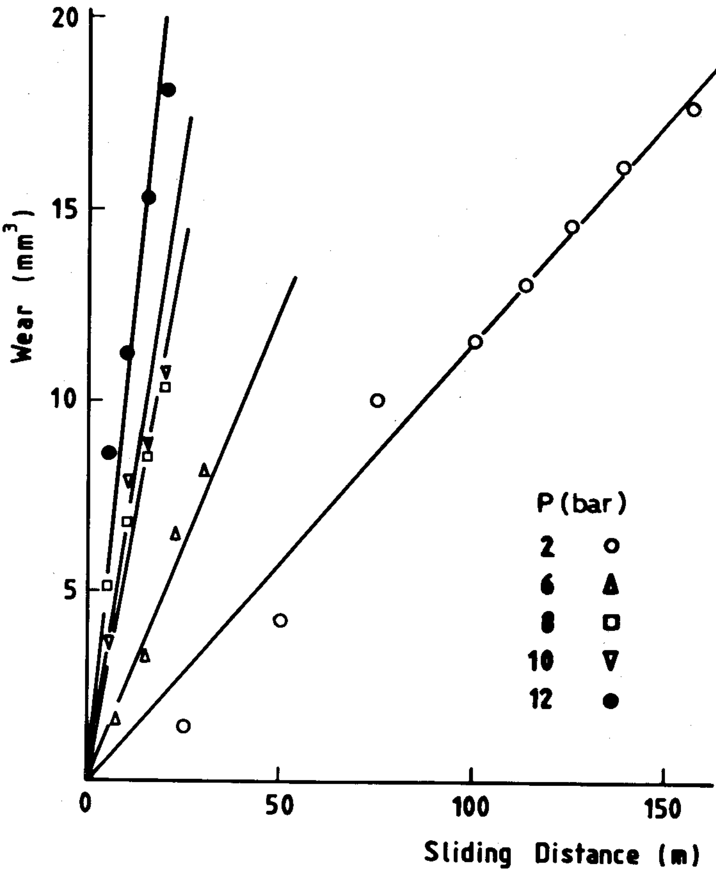


Fig. 4 : Relationship between Wear and Sliding Distance for different end loads.

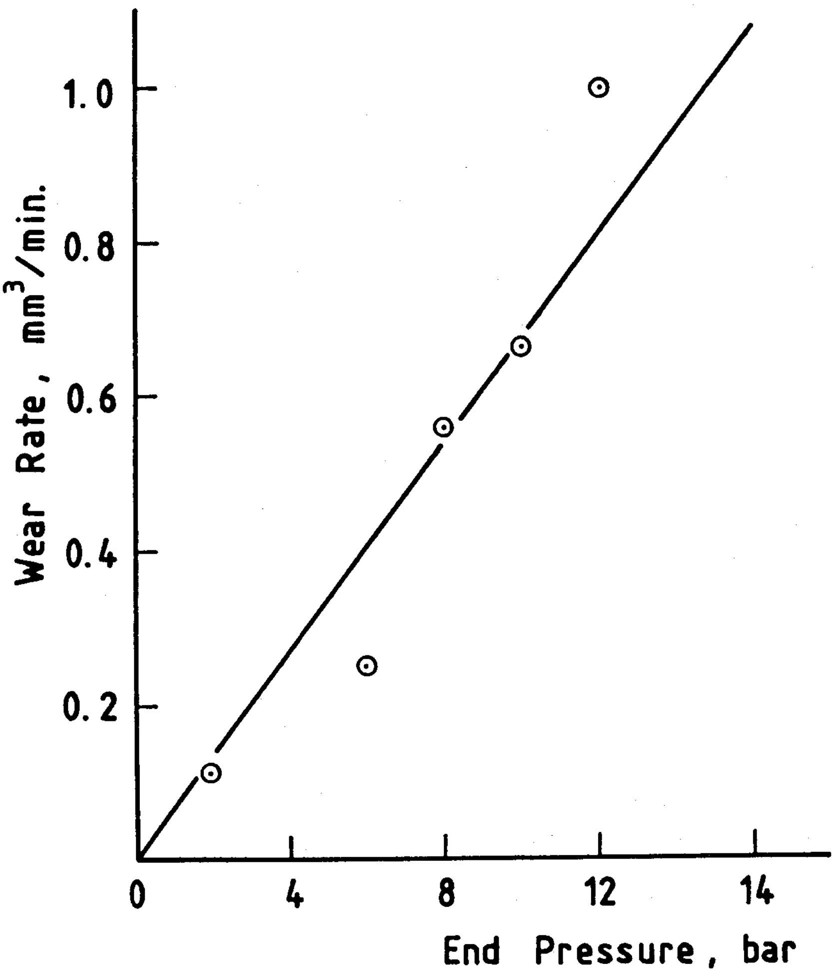
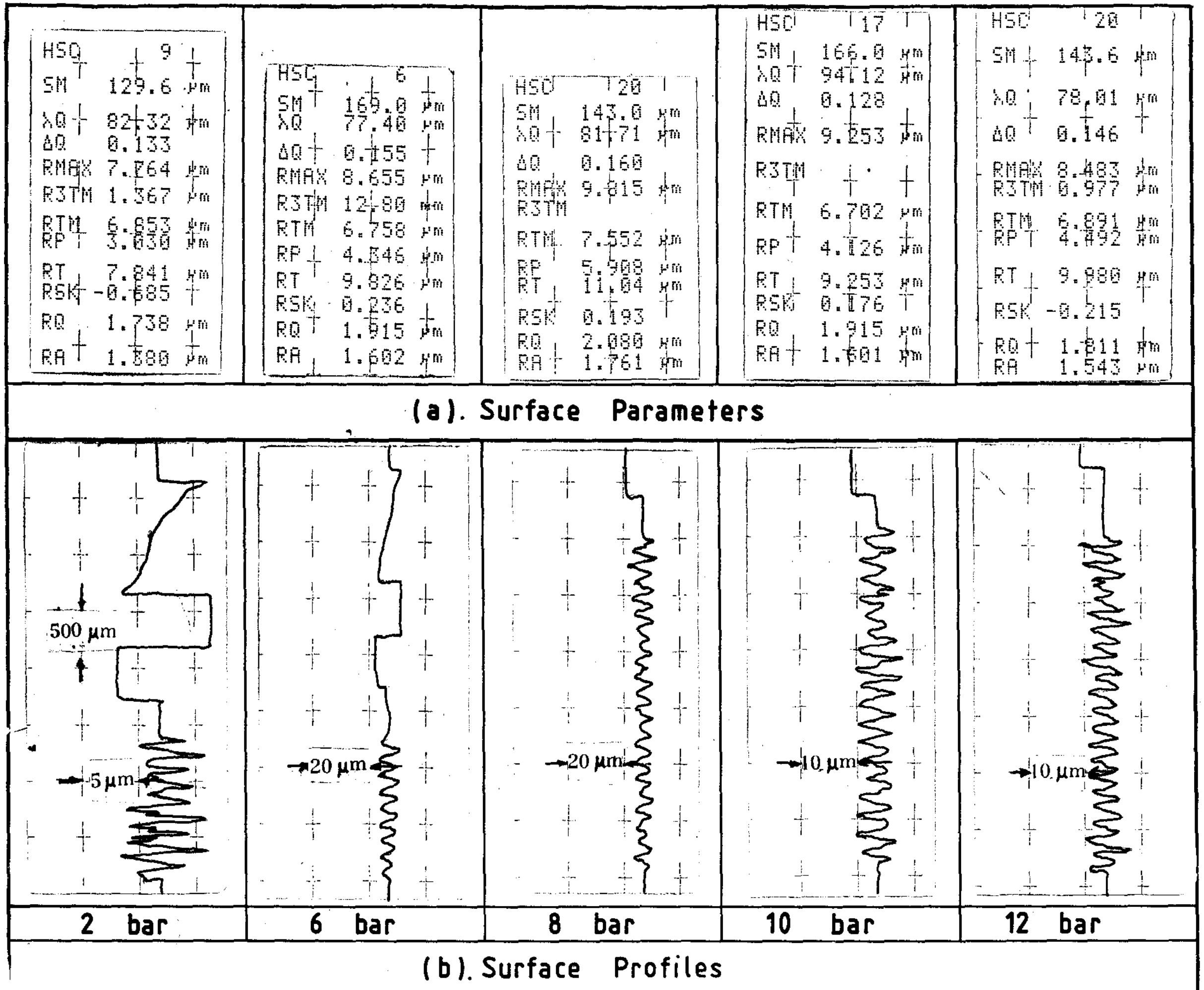
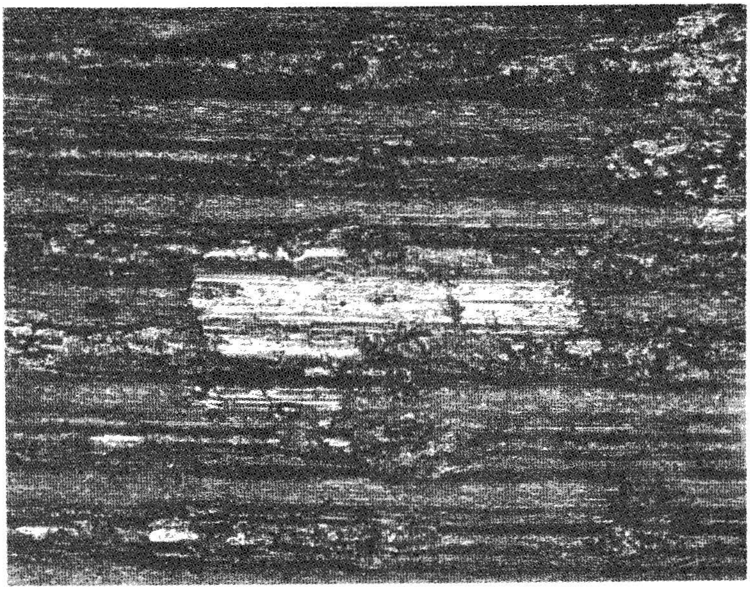


Fig. 5 : Relation between wear rate and end pressure.

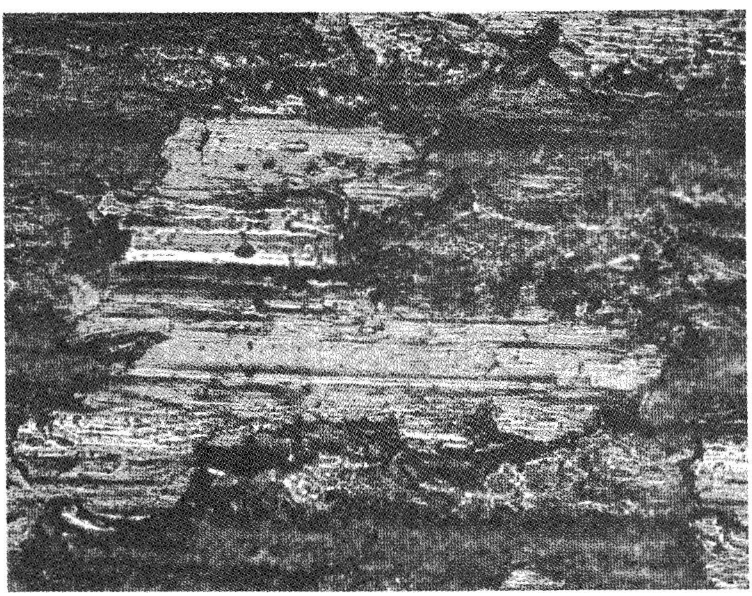
Microscopic examination of the steel disc revealed brass pick-up as shown in Fig. 7. Here, it should be recalled that the hardness of the pin material was lower than that for the disc material.



6 : **Surface Texture of Test Specimens.**



2 Cu/Steel (Disc)



4 Cu/Steel · (Disc)

Fig. 7 : Top view through optical microscope (magnification 200x) showing brass bick up on the disc material.

4. ANALYSIS OF THE EXPERIMENTAL RESULTS

The results obtained through the experimental procedure previously explained together with the values of the fixed parameters corresponding to each test condition were fed to the SPSS−PC statistical package. A multiple regression analysis was conducted on different sets of data. The model revealed the following results:

1. When values of the total volumetric wear (w), total sliding distance (d) and the end pressure (p) were fed into the analysis, (71%) of the variability in the volumtric wear (w) was accounted for by the sliding distance (d) and the end pressure (p) at a confidence level of 95% ($\alpha = 0.05$).
   The following linear equation was obtained:

$$w = 0.14387\ d + 1.09923\ p - 4.82732 \qquad (1)$$

2. A similar relation was achieved between the total volumetric wear rate (R) and the end pressure (p), (75%) of the variability in the rate (R) was accounted for by the end pressure (P) at a confidence level of 90% ($\alpha = 0.1$). The following linear equation was obtained:

$$R = 0.09609\ P - 0.14552 \qquad (2)$$

3. When surface parameters were introduced to the analysis as dependent variables together with (P) and (R), it was found that:

   a. Only 42% of the variability in the roughness arithmatic average (R_A) was contributed for by the end pressure (P) at a confidence level of 95% ($\alpha = 0.05$)

   b. 57% of the variability in the skewness parameter (R_{sk}) was contributed for by both the end tressure (P) and volumetric wear rate (R) at a confidence level of 90% ($\alpha = 0.1$).

   All other surface parameters did not meet the confidence limits indicated and were dropped out of the analysis. The following two equations were obtained:

$$R_A = 0.02304\ p + 1.39091 \qquad (3-a)$$

$$R_{sk} = 0.13824\ p - 0.71503\ R - 0.73093 \qquad (3-b)$$

5. CONCLUSIONS

(1) The volumetric wear, measured in (mm^3), for the brass specimens is significantly affected by, and directly proportional to, the change in both the end pressure and sliding distance.

(2) The volumetric wear rate in (mm^3/m), is significantly affected by, and directly proportional to, the applied end pressure.

(3) There is a linear relation between both the end pressure and the volumetric wear rate with the roughness of the pin surface.

(4) The roughness number (R_A) and the sqewness (R_A) are the only surface parameters influenced by changing the end pressure (P) and wear rate (R). The surface spacing and hybrid parameters showed no correlation.

(5) For practical applications, surface roughness of two rubbing metals could be predicted from the end pressure and wear rate at a high level of confidence.

REFERENCES

1. **N. Wuthrich,** "Materials Science and Wear", Sulzer Technical Review, Vol. 3, 1986, p. 37.

2. "Wear and Friction Machine", Plint & Partners Ltd., Berkshire, England, 1981.

3. **H. Dagnall;** "Exploring Surface Texture", Rank Taylor Hobson, 1980.

4. **M.A. Plint,** "Wear: A Review of Current Theories and Some Experimental Results", presented at Technical University of Maribor, Yougoslavia, Feb. 1974.